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General Comment

I Attach two documents.

A detailed submission and an annex.
These are both in Microsoft word.

I also send a copy by surface mail

Richard Wilson

Attachments

NRC-2008-0419-DRAFT-0019.1: Comment on FR Doc # N/A
NRC-2008-0419-DRAFT-0019.2: Comment on FR Doc # N/A

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Submission to the Nuclear Regulatory meeting on Security and Continued use of Radioactive sources
Docket ID: NRC-2008-0419

September 29th and 30th 2008

by:

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Sally Leivesey PhD
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General Annette Sobel, MD
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Submitted September 26th 2008

Introduction

The authors of this submission have been interested in countering sabotage and terrorism activities long before the events of 9/11/2001. They are now members of the Permanent Energy Montoring Panel for Mitigation of Terrorist Acts (PMP-MTA) of the World Federation of Scientists based in Geneva, Switzerland and meeting in Erice, Sicily. At its most recent meeting in May 2008 the PMP-MTA submitted a report on Risks of Dirty Bombs which was accepted by the August 2008 meeting, the 50th in a series, of the Seminar on Planetary Emergencies. We attach this report as an addendum to this submission.[1] In 2006, the PMP-MTA submitted a report[2] on mitigating the consequences of an attack with biological weapons. Several important conclusions of our group we feel are appropriate to bring to your discussions, and also some questions that our conclusions raise.

The first conclusion is that there are major qualitative distinctions between the effects of a terrorist attack with biological agents and a terrorist attack with radioactive sources. In the case of an attack with biological weapons it is not unreasonable to postulate that if there is no adequate preparation and response, a public health consequence could be as bad as the 1919 world wide influenza epidemic which killed about 80 million people world wide. On the other hand, the epidemic caused no damage to property and no areas were rendered uninhabitable The PMP-MTA report of 2007 specifically addressed simple steps to be prepared for such a pandemic and contain it. Responding to the use of a Radiological Dispersal Device (RDD) or "Dirty Bomb", is far simpler than responding effectively to an attack from a biological weapon—especially one that could induce a pandemic.

An RDD with high explosive dispersing a source of 50,000 Ci source strength, "Dirty

[1] "Responding to the Prospect of Dirty Dust (the residue from a radiological dispersal device--RDD)," by The Permanent Monitoring Panel on Mitigation of Terrorists Acts (PMP-MTA). Presented at World Federation of Scientists, Erice, Sicily, August 23, 2008. To be found at http://tinyurl.com/4yjgsd

[2] " 'Conquering Pandemic Flu by Practical Measures,' as adopted by the Mitigation Sub-Group of the Permanent Monitoring Panel on Terrorism of the World Federation of Scientists, Erice, Sicily, May 22, 2006. Membership of the Sub-Group on Mitigation Aspects: Dr. Diego Buriot, Dr. Kevin Clark, Professor Baruch Fischhoff, Professor Richard L.Garwin (Chairman), Professor Pervez Hoodbhoy, Dr. Sally Leivesley, Professor Ron Manley, Professor Richard Wilson." (at http://www.fas.org/rlg/060521-flu.pdf)

Dust" would, if quickly recognized, kill nobody, and cause very few cancers even on the usual pessimistic linear dose response relationship for cancers. But it could make several square km of area "out of bounds" for many years resulting perhaps of removal of all buildings therein. We emphasize in the 2008 PMP-MTA report that the area is critically dependent upon the acceptable standard for occupancy. It is therefore crucial that any discussion of policy for the use of radioactive sources for any purpose, including the medical applications considered here, and for purposes yet to be invented, consider this standard for acceptable reentry and use of areas contaminated with radioactive material.

Most calculations, including those of the PMP-MTA presented in our report make major simplifying assumptions. Firstly that the Radiological Disperson device had actually been detonated and all material was dispersed.[3] Secondly that no cleanup procedures were adopted. If calculations using these simplifying assumptions indicate no problem, then the discussion can stop here. However if calculations using these simplifying assumptions indicate a problem, and that major actions, such as expensive replacement of sources by other devices, are desirable, then it is crucial that a more complete risk analysis should be done. Such further analysis, and perhaps experimentation, discussed below, are likely to be far less expensive than banning or restricting any source. We urge that these be considered with high priority.

Specific Recommendations of the August 23, 2008 PMP-MTA report

1. *States should ensure registration and cradle-to-grave tracking of radioactive sources with strength greater than a few curies, with effective measures to avoid orphaned sources. International support should be available to expedite the process, since potential target states have an interest in securing sources wherever they may be.*

2. *It is obvious that states should cooperate in designing and implementing detection systems for intense sources of gamma-radiation-emitting radioactive materials as they might be shipped (usually in heavy shielding) from their origin to where they might be used in a dirty dust attack.*

3. *States and local authorities must cooperate with competent central authority and expert consultants to ensure that they can issue a previously prepared communication, within about 5 minutes after a dirty-dust attack, that contains an early assessment and initial instructions what to do—initially to stay or get inside buildings and to remove outer clothing that might be contaminated.*

4. *Medical resources and first responders must be organized both to make radiation measurements and to provide care at the site of a potential explosion and at improvised, non-hospital facilities to avoid contamination of hospitals. The public must be educated and prepared for "self-help" in advance of the incident to ensure optimized community outcome.*

5. *States must be prepared within 48 hours after a dirty-dust event to provide specific*

[3] In Ref. 1, as indicated in the caption to the figure, we do assume a fraction of the radioactive material 0.200 as "respirable."

assessment of the distribution of radioactive contamination and assurance to the many individuals, enterprises, and households that they can safely pursue their activities in an environment in which radiation can readily be detected but is essentially harmless. Other groups will be slated for relocation, the most heavily contaminated regions first.

6. *The projected individual integrated dose mandating relocation is about 100 milliSv, with relocation or cleanup (if possible) on a timely basis so that this reference level of 100 milliSv is not exceeded.*

Evidently individual localities cannot independently prepare for radiological or dirty dust attacks; the world must do this efficiently in appropriate working groups. But the "security culture" for radioactive sources is quite independent and feasible, and a "safety culture" for society must be inculcated—beginning with the optional and occasional mandatory use of marked Emergency Exits in public buildings.

Acceptable reentry levels.

The projected reentry level of 100 milliSv mentioned in Recommendation 6 above should be carefully considered. It is crucial to recognize the fact that, unlike most chemical and biological exposures, radioactivity and its accompanying radiation can be measured at very low levels. The fact that no one would be killed and few develop cancer is in such contrast to the effect of many everyday activities, that it suggests that some reentry into an area with measurable radiaoctive deposition should be permitted. Indeed that is unquestioned for normal everyday exposures and should be an option for exposures after an accident. The average radiation exposure for someone living in the mile high city of Denver exceeds that of Washington DC partially because of greater cosmic ray exposure and partially because of the larger radioactive mineral exposures in the region. Yet none of us are aware of any person who declines to go to Denver on that account. There is a variation in exposure around the average, yet we know of very few persons who are interested in measuring their personal background. Clearly evacuation to avoid an average exposure less than this difference, even on average, could be considered extreme. One should also consider whether some persons in the affected region could reasonably be considered "radiation workers" as two of us (RLG and RW) have been considered for 60 years. Such would be permitted regular entry, but radiation badges would be used.

We also note that there has been a strong tendency to regulate public exposures to radiation on the basis of PEAK individual rather than average exposures. We note that ICRP recommened that exposures to the general public from ordinary man-made activities be kept below 1.7 mSv/year on average, and that peak exposures above that level not be a matter of concern. This was based on probability of fatal cancer caused by radiation, and the societal concern is for the total number of such cancers not for the individual. Early non-cancer fatalities (within a month) do not occur below a peak individual dose of about 2 Sv within a month. We urge that the meeting be careful to recognize this important distinction between peak and average.

Clean up after an accident

There are two accident situations which are regularly quoted as indicating that cleanup is very expensive because the radioactive materials bind to the walls and the ground. The calculations presented in the PMP-MTA report assume no clean up. The first was on the release of a source of about 1,600 Ci, the size contemplated in your meeting, in Goiania, Brazil where 4 people died. But there was no immediate understanding of the problem and many of the exposures were almost deliberate, including spreading the skin with the glowing Cs-137 powder.

The second was on the area around the V.I. Lenin Atomic Energy Station at Chernobyl. The source was perhaps 100 million Ci and a large area was evacuated. Officially the public is not allowed in the exclusion zone. Although many older people defied orders and returned, and this has been condoned, there has been no widespread return.

Both these events occurred before a worldwide understanding of the cleanup problem. One of us (RW) has been to the area around Chernobyl several times. Although a wash down of the major streets was begun soon after the accident, and this had some measurable effect, it seems that wash down of buildings and apartments was not attempted until late. This leads to questions which we suggest that your meeting carefully consider

(1) How effective will an immediate washdown of the area around the dispersion site be? (before the material binds to the walls) And how does this depend upon the chemical form of the specific radioactive material, in contrast to the wide range of fission products and their chemical forms?. The concern in this particular meeting is on the chemical CsCl which is deliquescent. This suggests that a wash down would be particularly effective. We are aware of no experimental data on this, but it should be cheaper to acquire the most crucial data than to engage in the interminable discussions that take place without data. If clean up even by a small factor (2-5) is possible, this greatly reduces the area of concern.

One of us (RW) who has been using radiation even before his professional life began, has spilled small radioactive sources (up to 0.1 Ci). He has carried out cleanup within minutes and there in no case was there detectable residual radioactivity. He has also measured radioactivity at many locations both at the Chernobyl nuclear power plant and the surrounding area. For example in December 1987, he measured in two deserted apartments in Pripyat and expressed publicly his willingness to live in such a place. The Cs activity (including both Cs-137 with a 30 year half life and Cs-134 with a 2.2 year half life) would have been reduced several fold since then. Indeed a few plant workers were living there at the time during the work week. We suggest that before any further major action on restriction of sources for medical purposes is taken, that studies be undertaken on the effect of immediate cleanup. For example, it is not obvious that a change from a CsCl source to a powdered metal Cs source with a 28.4 degree C melting point, , which has been proposed because it is harder to disperse, may be unwise because it may also be harder to clean up.

Finally we suggest that a risk analysis be undertaken before any further regulatory action. This could include three major steps. Firstly a discussion of the security of the source an probability of it being chosen for a terrorist action; secondly a calculation of the effects of dispersion, and thirdly an estimate of the cleanup probability. The final numbers should be compared with the benefit of having the sources, including keeping alive the possibility that future societally beneficial uses can be found. In view of the time required to eliminate powdered Cs-137 sources worldwide, there is probably time to get right what we should be doing.

RESPONDING TO THE PROSPECT OF DIRTY DUST
(the residue from a radiological dispersal device--RDD)

by

The Permanent Monitoring Panel on Mitigation of Terrorist Acts
(PMP-MTA)[1]

World Federation of Scientists
Erice, 27-28 May 2008

Abstract: The major impact of dirty dust (the product of a radiological dispersal device) is likely to be the economic loss associated with the inability to occupy buildings for some years after the event. Few deaths are to be anticipated from the radiation exposure. But if panic is to be avoided, authorities must plan and practice immediate substantive instructions to the public. Unwarranted economic loss will be incurred unless reasonable action levels are agreed and implemented.

The major physical impact of dirty dust from a radiological dispersal device—RDD—is likely to be an area of a city contaminated with radioactive material that under strict regulations of environmental protection could not be occupied for a time typically measured in months to years. This is so whether the radioactive material is spread by a high explosive device or is volatilized from solution in an "atomizer" or spray system.

While mass casualties or deaths of 100,000 or more might result from an improvised nuclear explosive or from a large attack with a biological (disease) agent such as anthrax or smallpox, the dissemination of radioactive material is likely to kill far fewer—if any.

We assume that the purpose of terrorism is usually to induce terror and hence to undermine the legitimacy of government, to cause disruption and economic loss, and to induce political change. A reasonable assessment of the hazards and risks of terrorism (probability of occurrence multiplied by the damage caused if the incident occurs) can guide prevention and response, and reduce the component of terror induced. It is possible that dirty dust might be combined with other terrorist acts; a vehicle bomb or small

[1] Diego Buriot, Richard Garwin (Chair), Vasily Krivokhizha Sally Leivesley, Alan Leigh Moore, Ramamurti Rajaraman, Annette Sobel, Friedrich Steinhaeusler, Richard Wilson

explosive rocket can combine the familiar destruction from explosives with the potential panic from radioactivity.

An RDD has nothing in common with a nuclear explosion. A common term, "dirty bomb" unnecessarily confuses the two; we will use the term "dirty dust," whether the radioactive material is spread by explosive means or not[2]. The dirty dust would typically be radioactive material from a common industrial or medical "source" of radiation measured in curies—Ci—or in terabecquerel—TBq. One curie is 37 billion disintegrations per second, or 0.037 TBq. A typical source strength of Co-60 or Cs-137 for hospital cancer treatment is 3000 Ci or 100 TBq, while radiation sources for blood irradiation or for polymerizing plastics may be in the range of 10,000 TBq. The accidental contamination of the town of Goiania, Brazil, by a Cs-137 source amounting to 1600 Ci (50 TBq) killed 4 people, exposed 250 to radioactivity and resulted in 3000 cubic meters of radioactive debris from the cleanup. A recent pictorial account is given in IAEA Bulletin 49-2 March 2008, page 28.

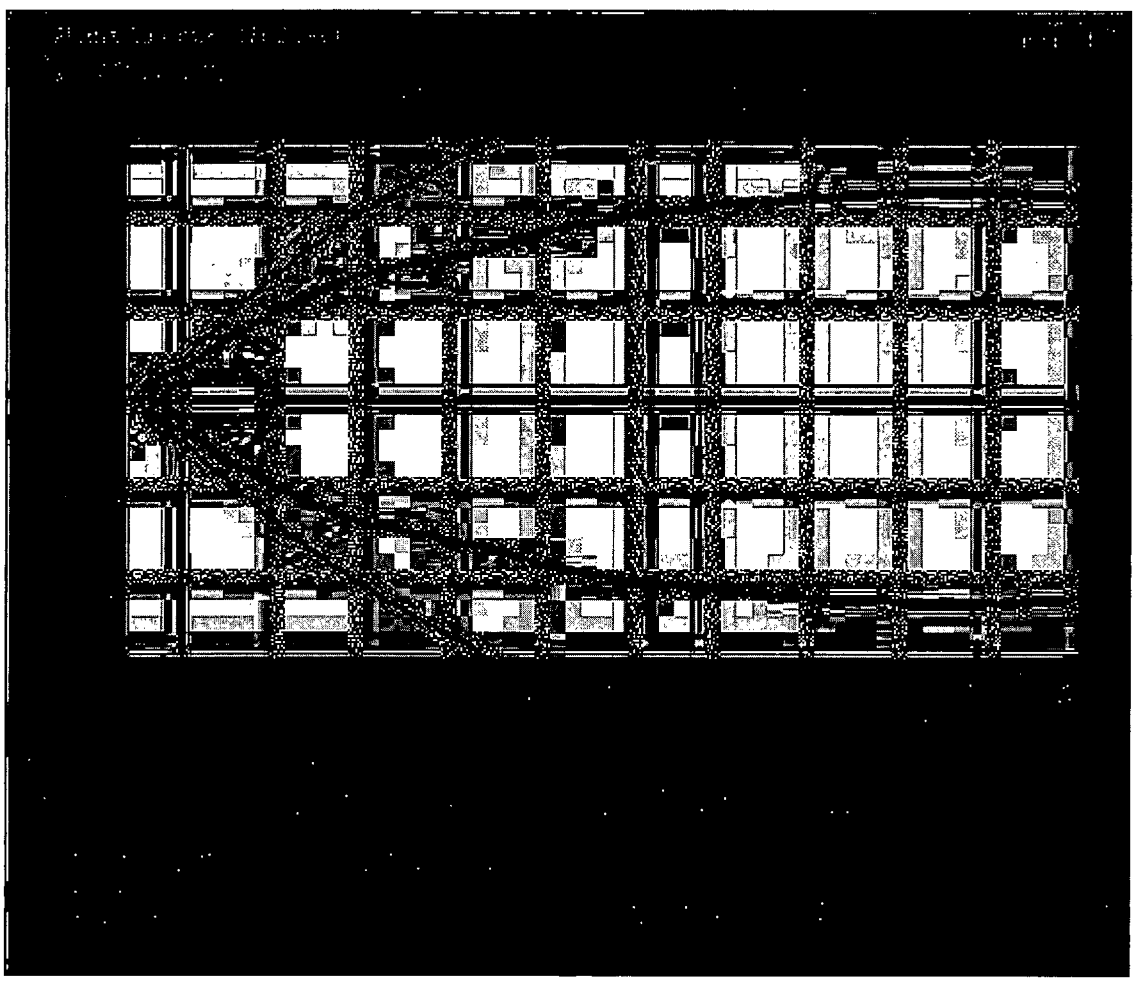
EFFECTS OF EXPLOSIVE RELEASE OF DIRTY DUST

In the vicinity of an explosive release of dirty dust, people who are in the open are more likely to be injured or killed by the explosion itself, and heavily contaminated with radioactivity. Beyond a few tens of meters there will be only the radioactivity of concern, and the health effects are due to the "dose"—the product of "dose rate" and exposure time. Typically, most of the radioactivity will be in the form of grains or palpable dust

[2] A ground-level nuclear explosion of 10 kiloton yield—compared with the 13-kt air burst at Hiroshima—would produce "fallout" of the radioactive material resulting from the fission of 600 grams of uranium or plutonium. The 30-year half-life Cs^{137} "fission product" would amount to about 50 grams or 5000 Ci. In addition there would initially be far more intense radioactivity from fission products of shorter life that would be lacking in dirty dust. At one hour after the nuclear explosion, the dose rate from penetrating gamma radiation from fission products is 100 million times what it will be at 25 years post detonation ("The Effects of Nuclear Weapons," Figs. 9.16a and 9.16b, www.**princeton**.edu/~globsec/publications/effects/effects9.pdf). The intensely radioactive short-lived fallout from the ground-level explosion would likely kill tens of thousands of people who would otherwise have been untouched by the blast or heat of the nuclear explosion.

and will settle out within tens or hundreds of meters of the explosion; a fraction, perhaps small, fine enough to be inhaled (respirable) will be carried to tens of km or more, depending on the physical state of the radioactive material, the wind, the roughness of the terrain, and whether there is a temperature inversion. Figure 1 shows as an example for an RDD a typical result from dispersal of cobalt (Co-60) as dirty dust.

Figure 1: Cobalt (Co-60)-based dirty dust--total effective dose equivalent (TEDE)-contour plot in an urban environment (Co-60 activity: 37 TBq or 1000 Ci; explosives: about 50 kg TNT)[3] (from F. Steinhauesler).



[3] **Dose Equivalent**: A "quality factor" is used to convert absorbed doses to a quantity, the dose equivalent, which can be directly compared with other converted absorbed doses (for the same organ), and whose magnitude is proportional to the amount of potential biological damage caused by the absorbed dose. Dose equivalents are measured with the unit of sievert

Effective Dose Equivalent (EDE): Dose equivalent to the individual organs can be combined (through the use of tissue weighting factors) to calculate the sum of the dose equivalents as applied over the entire

The relevance of the sievert—Sv—is that a dose of 4 Sv in a short time is likely to produced acute radiation sickness with death within weeks, while 0.20 Sv will result in a 1% probability of death by cancer after a delay of 10-20 years or more.. The middle contour of 10 microSv TEDE corresponds to about one additional death by cancer[4] for each two-million people exposed at that level, and is the limit sometimes recommended by the IAEA (for an unavoidable exposure deemed "negligible").[5] Many cities have peak population density regions of some 40,000 people per square kilometer[6], so that the 2.4 km^2 area of the middle contour would contain some 90,000 people. Without knowing the dose at each point within this 2.4 km^2 area, it is clear that it is less than the 100 microSv dose of the inner contour, so that the total collective dose cannot exceed 9 Sv; the expected cancer deaths without relocation are thus 0.05 x 9 = 0.45 total. Probably not a single cancer death outside the 0.024 km^2 contour, which itself might contain only 1000 people; it would be difficult to justify costly cleanup or restrictions on occupancy outside this 2.4 hectare (5.9 acre) boundary.

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body. When this is done the resulting dose is the Effective Dose Equivalent (EDE).

Committed Dose Equivalent (CDE): The Committed Dose Equivalent (CDE) is the dose equivalent that will be delivered to a particular tissue or organ (lung, liver, thyroid, etc.) of the body over a specific time interval, e.g. in this calculation over the next 50 years after intake of the material. The dose is calculated by multiplying the integrated air concentration by the dose conversion factors (DCF).

Committed Effective Dose Equivalent (CEDE): Sum of the CDE to the individual organs and tissues (using the appropriate weighting factors) to calculate a combined dose as applied over the entire body.

50-Year Committed Effective Dose Equivalent (CEDE): The 50-year committed effective dose equivalent (Sv) received by an individual due to remaining at the specified location throughout the entire radioactive material release. This value is the sum of the 50-Year Committed Dose Equivalents to various tissues in the body, each multiplied by the appropriate weighting factor.

Total Effective Dose Equivalent (TEDE): The Total Effective Dose Equivalent (TEDE) is the sum of the EDE (caused by the external material) and the CEDE (caused by the internal material) from all applicable delivery pathways. The EDE from 4-days of ground shine is included in the TEDE value,

[4] Using the ICRP coefficient of 0.05 cancer deaths per person-Sv.

[5] "Health and Environmental Impacts of Electricity Generation Systems: Procedures for Comparative Assessment," IAEA Technical Reports Series No. 394 treats as "negligible additional radiation" exposures comparable with the natural background of some 3 milliSv per year. But one finds in IAEA-TECDOC-1484 Regulatory and management approaches for the control of environmental residues containing naturally occurring radioactive material (NORM), (www-pub.iaea.org/MTCD/publications/PDF/te_1484_web.pdf). P. 20:

"• The additional individual dose attributable to the exempted source should be of the order of 10 μSv per year or less; and

"• Either the collective dose to be committed by one year of performance of the practice should not be more than about 1 man-Sievert or exemption should be the optimum option."

[6] http://www.demographia.com/db-citydenshist.htm (Selected Current and Historic City, Ward & Neighborhood Densities, P. 4 of 24)

The crucial point, to be addressed later, is the habitability of buildings and the use of this 10 microSv TEDE or an alternative action criterion in RDD (dirty-dust) attacks. Note that if the position expressed in IAEA TRS394 is assumed to govern allowable radiation exposure, under the linear hypothesis those exposed to 3 milliSv per year would have an additional lifetime probability of death by cancer of 150 per million people for each year subject to such additional exposure, to be compared with a near-universal 20% of deaths caused by cancer—equivalent to 20%/60 = 3300 per million people per year of life. The difference between 10 microSv/yr and 3 milliSv/yr is an impressive factor of 300. We prefer to quote the expected deaths from cancer under the ICRP recommended coefficient[7] of 0.05 cancer deaths per person-Sv, to allow States and localities to make informed policy choices.

Evidently, reducing the likelihood of such an incident is highly desirable. This can be accomplished by reducing the motivation for terrorism or by interfering with the commission of the act, for instance by "cradle-to-grave" security and accounting of the potential sources of radioactivity. Evidently, radioactive sources should be secured, alarmed, and accounted for in accordance with the harm that might be caused if misused. In general, a global "security culture" for radiation sources must be inculcated. In particular, powdered Cs-137 compounds in sources should be replaced by forms more difficult to disperse. The need for security culture and other measures to reduce terrorist access to radioactive materials is a worldwide problem, for which international support is warranted. This is essential since, at least at present, the countries that are origins of radioactive sources and of perpetrators for such attacks are likely to be different from the potential target countries. The former generally have a much more lax system of security than the latter.

7 ICRP-60. Quoted as "For members of the public, ICRP currently assesses the probability of fatal cancer due to radiation to be in the order of 5 % per 1000 person mSv (assuming a collective dose comprising low individual doses to many persons). In addition, ICRP suggests that non-fatal cancers and genetic disease should be taken into account in risk assessments. For such diseases, the severity must be taken into account - it is obviously less traumatic to survive a cancer than to die from one." at http://www.npcil.nic.in/nupower_vol13_1/icrp1n.htm

If there were a widespread deployment of radiation detectors reporting in real time, it might be possible to interfere with the transport by suicide bomber of many types of sources to the desired point of detonation, provided they are emitting gamma radiation.

Terrorist events do not come neatly labeled as "RDD."[8] Dissemination of radioactivity[9] by non-explosive methods may not even be recognized immediately as a significant event, as indeed the Brazil release was not immediately recognized. Whenever there is an explosion, the fire brigade, police, or paramedics should ideally come equipped with a standardized high-dose-rate detector of radiation, (and a knowledgeable user thereof), to determine whether there is an RDD component to the attack, and standard operating procedures must be defined and repeatedly practiced to assess and begin the response to such an event. The usual radiation detector would not respond should the terrorist have selected an alpha-particle emitting radiation source, although there are robust specialized detectors that would be suitable.

MANAGING POPULATION RESPONSE TO DIRTY DUST

News moves fast and informally in the modern information-rich society. If the population is not to panic from news of a "radiation attack," the local authorities must have worked together with competent central authority and expert consultants to issue a previously prepared and "socialized" communication, within about 5 minutes, that contains an early assessment and initial instructions what to do. This report would be "pushed" immediately to all who are interested in such a "feed" and the local community alerted. Such instructions and auxiliary information must also be provided on the web and across public information channels in a form readily and permanently accessible and one that will not be overwhelmed by the ensuing queries. The direction of the plume of dirty dust and immediate protective actions to be taken should be part of the initial report and updates made available.[10]

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[8] or as "ordinary explosives", "chemical agent" or "bio attack."
[9] or chemical or bio agent
[10] The (US) National Atmospheric Release Advisory Center at https://narac.llnl.gov/ is a valuable resource for planning and for managing an atmospheric release of radioactivity or of a bio-agent.

First responders and health professionals are dedicated to saving lives and to caring for the wounded, vulnerable, or exposed; but they must be protected from injury themselves. First responders must be empowered with knowledge and support; it should not be taken for granted that they will all accept to respond to such events. It is critically important to maintain their motivation to volunteer for such service, and ensure that means will be provided for protection of their families while they are serving.

Members of the public at some distance from the event should ordinarily remain indoors in place until the situation is assessed, while those who are contaminated with radioactive materials must help themselves to reduce continuing exposure. Much of this decontamination would have to be handled by members of the public themselves; as they enter buildings for shelter from the passing cloud of dirty dust, they should remove their shoes and outer clothing. Buildings with heating, ventilating, and air conditioning—HVAC—systems should be able to close their air inlets until the cloud of radioactivity passes by, so as to reduce radioactive contamination inside the buildings and to accommodate "shelter in place" until the plume of radioactivity has passed.

INTEGRATED MEDICAL RESPONSE

Contaminated individuals should not be taken to hospitals, which might as a result become so contaminated that their ordinary use would be impaired. Instead, improvised facilities should be planned, including the provision of rooms or tents with positive pressure air flow that could be provided in facilities with open interior space. Although few people may actually require urgent care in an RDD event, a very large number might demand admission to normal urgent care facilities, and immediate psychological support, not only overwhelming such facilities but contaminating them so that they could no longer be used.

Radiological terrorism thus presents a unique set of global medical challenges and the necessity for public self-help. Among these challenges are ensuring public situation awareness and community preparedness, timely casualty triage, and expeditious acute and definitive treatment. The policy recommendations include field expedient placement and management of casualties in distributed contingency facilities using specially trained medical personnel in the context of leveraging existing medical infrastructures, including public health. "Contingency" facilities may include ships, warehouses and sports stadiums, and other nontraditional facilities such as mobile medical modules, and should be accompanied by "lock-out" of hospital facilities to radiological injuries. Lock-out will require enhanced physical security and public education to enhance cooperation.

Mass casualty management requires the use of expedient facilities such as tents that will also accommodate stabilization of combined injury patients such as surgical patients. This will require an integrated response plan in which medical is central to logistical support and allocation of resources such as communication bandwidth, logistics support, supplies, and transportation. Rather than a gradual approach to medical resource build-up, urgent medical care should be particularized for more expedient logistics and care at the point of injury.

In the special case of dirty-dust incidents in the urban underground, the medical management should occur proximate to the site of injury with cooperation of rail personnel to expedite transport of casualties. Respiratory protection is essential for prevention of continued inhalation exposure and use of a small blower providing locally filtered air in an expedient air-inflated shelter is recommended for response personnel and injured patients.

There is an important role for experiment in preparing to respond to dirty dust events, such experiment ranging from the psychosocial to the physical-chemical. Among the latter, for instance, is the determination of the potential benefit of pre-wetting by a gentle spray of water on the exterior of various types of buildings, in reducing contamination by (simulants of) radioactive materials. The attempted cleanup of Pripiyat suggests that most buildings in a region of radioactive contamination too intense for continued occupation will more economically be razed and rebuilt, but that is a matter for experiment to determine the cost of various approaches to removing dirty dust from the real built environment. Critical to this determination is the setting of a threshold for continued occupation of housing or the use of business facilities.

In our 2006 report[11] on fighting pandemic influenza, this group emphasized self-help and personal protective measures (PPM):

> "Even if the efficacy of PPM were demonstrated in a test evaluation, which is not yet the case, it is clear that relatively few in society would be ready to use such measures if the necessity presented itself, in the absence of sound information as to what to do and how to do it. The information does not move itself; major staff resources and effort would need to be expended to evaluate the effectiveness not only of the PPM but of the means of communication and persuasion that could be used via schools, place of employment, clubs, pharmacies, and faith-based organizations to persuade people that they should equip themselves and practice the PPM."

The problem of dirty dust is much simpler than that of pandemic flu or other contagion because the radioactivity is far easier to detect and to assess quantitatively. Nevertheless, the response to dirty dust must be defined and demonstrated. It must be interpreted into language, sketches, and video for the public. And the public must be motivated by popular leadership to learn the simple tools that will reduce the hazard to them,

- Stay put
- Stay clean
- Pay attention to authoritative advice regarding staying indoors or resuming normal life.

Naturally, official advice on the dirty dust event will not stop at the 5-minute point; it will continue to be available and will be updated. But by the 2-day post-event point (48 hours) it is essential that definitive official information be available as to neighborhoods that are clearly safe for indefinite occupancy, those clearly safe for occupancy up to a month, and those that might be subject to relocation after a few months. That the radiation is easy to detect has both positive aspects and negative aspects. Cleanup to even a minute exposure level can easily be defined although it becomes progressively more expensive as the cleanup level is reduced. In the aftermath of Chernobyl, cleanup levels previously

[11] http://www.federationofscientists.org/PMPanels/Terrorism/erice_PMPT_2006_Final_Report.pdf

discussed by ICRP were reduced by many jurisdictions. Instead of using the "new" low clean up levels, a major reduction in the cost and harm of an RDD incident would come from action by the competent authorities to provide a more realistic balance of benefits vs. risks from radiation. This would entail establishing a level for Exemption, Clearance, or Authorized Release for certain areas and incidents, compatible with official survey and labeling of the average exposure levels expected during the emergency and recovery period. For instance, if public authorities adopted the IAEA consideration of 10 microSv/year[12] (= 0.01 milliSv/yr) as "trivial" and mandated evacuation of the public from areas projected to provide such a trivial dose, the expected saving of life, based on the theoretical linear dose-response curve, would be one for every 2 million people living in a zone receiving that modest exposure from dirty dust.

Typical background radiation experienced by the public is some 3 milliSv/year (3 milliSv/yr or 3000 microSv/yr), of which half comes from diagnostic medical or dental procedures—a factor 300 above the criterion of "negligible radiation". There seems to be no public concern about living in regions with even double this dose. For a uniform distribution of a given amount of dirty dust, choosing the 0.01 milliSv/year criterion can result in the forced evacuation of 300 times the area as would be required at the 3 milliSV/year[13] level. Specifically, for the radioactive material Co-60, a ground contamination level of 1000 disintegrations per second per square meter (1 kilobecquerel/m^2 or 1 kBq/ m^2) provides an exposure to a person of about 70 microSv/year (= 0.07 milliSv/yr). To double the normal background exposure of 3000 microSv/year would thus correspond to contamination averaging 43 kBq/m^2 or 43 GBq/km^2—about 1.2 curie/ km^2.

A criterion that might be used by authorities and individuals is to compare an inferred life-value of $1-6 million with the cost of relocation, which might be $20,000 per person. A person valuing his or her life at $5 million might decide to relocate at the cost of

12 There seems to be an unresolvable confusion between the positions of the IAEA (or expressed at IAEA conferences) that variously judge 10 microSv/yr or 3000 microSv/yr as trivial or negligible.

13 Even that dose is far less than the 200 milliSv integrated dose allowed in one year for clean up workers at Chernobyl, or the 800 milliSv allowed for an astronaut in one trip.

$20,000 if by so doing a probability of death of $20,000/$5 million = 0.4% could be avoided. At 0.05 probability of death per Sv of exposure[14], 0.4% would correspond to 80 milliSv, or some 27 years of 3 milliSv/year background radiation. Because Co-60 has a half-life of 5 years, an initial dirty-dust contamination of 5 Ci/km^2 would give a total external dose of 80 milliSv to a person within the area who did not benefit from any shielding and remained in the contaminated area for many years. There is no treatment known that will reduce the incidence of cancer from the radiation from either natural radiation background or from dirty dust.[15]

OPTIMIZING RESPONSE TO MINIMIZE RADIATION EXPOSURE AND ECONOMIC LOSS

We support the IAEA 2007 recommendations that in emergencies, reduced exposure to radiation should be subject to *"The Principle of Optimization of Protection: The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors."* In this spirit, we recommend that the population not attempt to evacuate their homes and businesses during the early minutes and hours when there would be exposure to a cloud of dirty dust.

After the situation is assessed, the population threatened only with the residual radiation from dirty dust must be considered for gradual relocation if the projected dose cannot be reduced below the ICRP *Reference Level* of 100 milliSv. In this regard the analysis, above, in the case of an 80 milliSv dose from long time exposure to Co-60 is relevant.

Recommendations

1. States should ensure registration and cradle-to-grave tracking of radioactive sources with strength greater than a few curies, with effective measures to avoid

[14] The coefficient proposed by the ICRP.
[15] Once a person has taken up radioactive dust orally or by inhalation, there is also the limited possibility to induce enhanced excretion of the radioactive dust incorporated, e.g., by EDTA treatment. Potassium iodide pills taken before exposure to the plume from a nuclear reactor accident can block the uptake of radioactive iodine and reduce the threat from thyroid cancer but do not reduce any other radiation-induced cancer risk.

orphaned sources. International support should be available to expedite the process, since potential target states have an interest in securing sources wherever they may be.

2. It is obvious that states should cooperate in designing and implementing detection systems for intense sources of gamma-radiation-emitting radioactive materials as they might be shipped (usually in heavy shielding) from their origin to where they might be used in a dirty dust attack.

3. States and local authorities must cooperate with competent central authority and expert consultants to ensure that they can issue a previously prepared communication, within about 5 minutes after a dirty-dust attack, that contains an early assessment and initial instructions what to do—initially to stay or get inside buildings and to remove outer clothing that might be contaminated.

4. Medical resources and first responders must be organized both to make radiation measurements and to provide care at the site of a potential explosion and at improvised, non-hospital facilities to avoid contamination of hospitals. The public must be educated and prepared for "self-help" in advance of the incident to ensure optimized community outcome.

5. States must be prepared within 48 hours after a dirty-dust event to provide specific assessment of the distribution of radioactive contamination and assurance to the many individuals, enterprises, and households that they can safely pursue their activities in an environment in which radiation can readily be detected but is essentially harmless. Other groups will be slated for relocation, the most heavily contaminated regions first.

6. The projected individual integrated dose mandating relocation is about 100 milliSv, with relocation or cleanup (if possible) on a timely basis so that this reference level of 100 milliSv is not exceeded.

7. Evidently individual localities cannot independently prepare for radiological or dirty dust attacks; the world must do this efficiently in appropriate working groups. But the "security culture" for radioactive sources is quite independent and feasible, and a "safety culture" for society must be inculcated—beginning with the optional and occasional mandatory use of marked Emergency Exits in public buildings.